International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 5, Oct 2018, 241-248

OPTIMIZATION OF PARAMETRES FOR WELDABILITY STRENGTH – AN EXPERIMENTAL DESIGN APPROACH

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ABSTRACT

It is necessary to study the input parameters of welded product, to gain a 'welded joint' with good quality. The influence of welding parameters such as welding current, welding voltage and welding speed will show a significance effect on a welded joint. By using design of experiment method, the parameters can be optimized and made to have the best parameter combination for target quality. An orthogonal array, Signal to Noise(S/N) ratio have been employed to study the welding characteristics of material and optimize the welding parameter. The result has been computed using the form of contribution from each parameter, through which optimal parameters are identified for maximum tensile strength. The chosen parameters and obtained tensile strength results are analysed by using Minitab software, the calculations are done, results are generated and optimum results are obtained.

KEYWORDS: MIG Welding, Steel, Taguchi Technique, Tensile Strength & MINITAB Software

Received: Jul 02, 2018; **Accepted:** Jul 23, 2018; **Published:** Sep 03, 2018; **Paper Id.:** IJMPERDOCT201827

Original Article

INTRODUCTION

Metal Inert Gas (MIG) welding is well known and most widely used arc welding process in today's world. It is used to weld verity of materials, ferrous and non-ferrous. The weld quality of MIG welding largely depends on the various process parameters, viz. current, voltage, shielding gas flow rate, welding speed, wire feed rate, electrode angle, wire diameter, arc length etc. In the present investigation, effect of three important parameters; welding current, voltage and speed of weld are studied, and optimized for tensile strength of the weld. MIG arc welding is performed on low carbon steel and high carbon steel. An experiment has been designed using Taguchi L9 Orthogonal Array (OA) for the current study. For the selection of the input process parameters and their levels, various published literature were studied, and the already stated three parameters with three levels each were chosen.

OBJECTIVE OF PRESENT WORK

The objective of the present work is to investigate the effect of three important input parameters of MIG welding with two different materials i.e. low carbon and high carbon steel visible in different geometry; three parameters are current, voltage and weld speed are varied for welding to determine the Tensile Strength of joints, and to optimize the input parameters for maximum welding strength in tensile strength of weld.

METHODOLOGY

To satisfy the above requirement, an experiment has been designed using Taguchi's experimental design technique. From various literature surveys, the following three factors with three levels each are selected as shown in TABLES for two different materials:

Levels for Low Carbon Steel

Table 1

Parameters	Level 1	Level 2	Level 3
Welding Current	180	190	200
Welding Voltage	23	25	27
Speed	200	250	300

Levels for Medium Carbon Steel

Table 2

Parameters	Level 1	Level 2	Level 3
Welding Current	210	220	230
Welding Voltage	24	26	28
Speed	150	200	250

Column Assignment of the Factors Orthogonal Array for Low Carbon Steel

Table 3

Experiment	Current (amps)	Voltage (volts)	Speed (mm/min)
1	180	23	200
2	180	25	250
3	180	27	300
4	190	23	250
5	190	25	300
6	190	27	200
7	200	23	300
8	200	25	200
9	200	27	250

Column Assignment of the Factors Orthogonal Array for Medium Carbon Steel

Table 4

Experiment	Current (amps)	Voltage (volts)	Speed (mm/min)
1	210	24	150
2	210	26	200
3	210	28	250
4	220	24	200
5	220	26	250
6	220	28	150
7	230	24	250
8	230	26	150
9	230	28	200

MATERIAL AND SPECIMEN DRAWING OF MATERIALS

Low Carbon Steel

Typically, this contains 0.04% to 0.30% carbon content. It is one of the largest groups of Carbon Steel. It covers a great diversity of shapes; from Flat Sheet to Structural Beam. Depending on the desired properties needed, other elements are added or increased.

Material Composition

Table 5

Element	Weight in %
Carbon	0.14-0.20%
Sulphur	<0.05%
Phosphorus	<0.04%
Manganese	0.6-0.9%

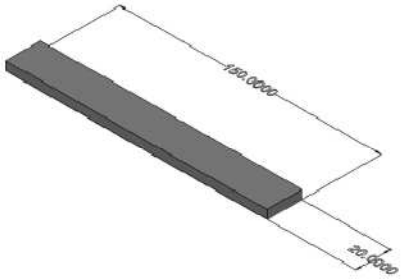

Figure 1: Specimen Drawing

Medium Carbon Steel

MCS steel typically has a carbon range of 0.31% to 0.60%, and a manganese content ranging from .060% to 1.65%. This product is stronger than low carbon steel, and it is more difficult to form, weld and cut. Medium carbon steels are quite often hardened and tempered using heat treatment.

Material Composition

Table 6

Element	Weight in %
Carbon	0.36-0.4400
Silicon	0.1-0.4
Sulphur	0.05 Max
Phosphorus	0.05 Max
Manganese	0.6-1.0

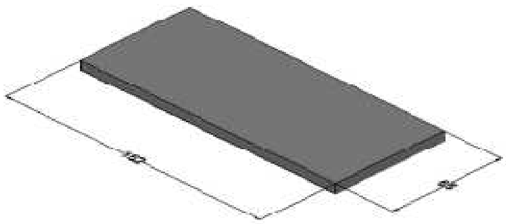

Figure 2: Specimen Drawing

EXPERIMENTAL ANALYSIS AND RESULTS

Table 7: Tensile Values for the Low Carbon Steel

S. No	Current	Voltage	Speed	Strength
1.	180	23	200	28.75
2.	180	25	250	23.7
3.	180	27	300	26.4
4.	190	23	250	11.3
5.	190	25	300	39.5
6.	190	27	200	30.5
7.	200	23	300	25.75
8.	200	25	200	18
9.	200	27	250	33.5

Table 8: Table Tensile Values for the Medium Carbon Steel

S. No	Current	Voltage	Speed	Strength
1.	210	24	150	67.5
2.	210	26	200	111.0
3.	210	28	250	52.0
4.	220	24	200	64.0
5.	220	26	250	84.0
6.	220	28	150	101.0
7.	230	24	250	97.5
8.	230	26	150	95.5
9.	230	28	200	68.0

Obtained S/N RATIO for the Low Carbon Steel

Table 9

S. NO	Current	Voltage	Speed	Strength	S/N Ratio
1.	180	23	200	28.75	29.17
2.	180	25	250	23.7	27.49
3.	180	27	300	26.4	28.43
4.	190	23	250	11.3	21.06
5.	190	25	300	39.5	31.93
6.	190	27	200	30.5	29.68
7.	200	23	300	25.75	28.86
8.	200	25	200	18	25.10
9.	200	27	250	33.5	30.50

Obtained S/N RATIO for the Medium Carbon Steel

Table 10

S. NO	Current	Voltage	Speed	Strength	S/N Ratio
1.	210	24	150	67.5	36.58
2.	210	26	200	111.0	40.90
3.	210	28	250	52.0	34.32
4.	220	24	200	64.0	36.12
5.	220	26	250	84.0	38.53
6.	220	28	150	101.0	40.08
7.	230	24	250	97.5	39.78
8.	230	26	150	95.5	39.60
9.	230	28	200	68.0	36.65

Taguchi Analysis Graphs for Low Carbon Steel

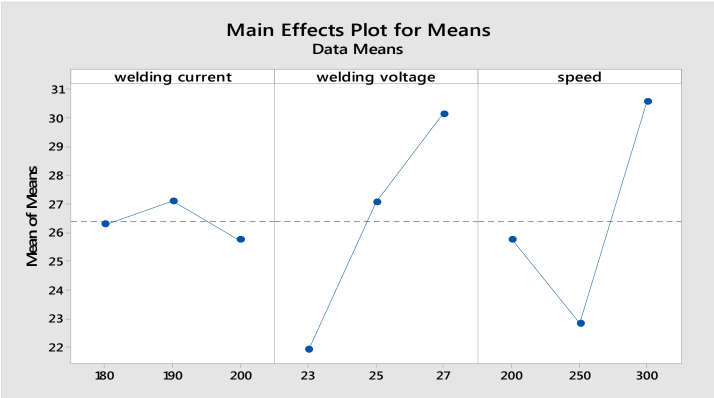

Figure 3: Main Effect Plot for Means for Low Carbon Steel

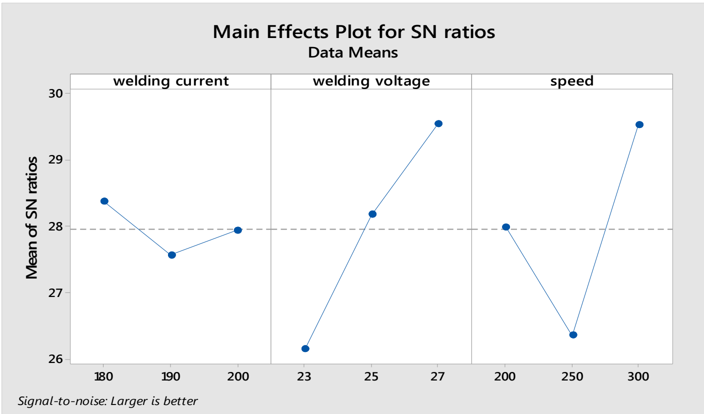

Figure 4: Main Effect Plot for S/N Ratio for Low Carbon Steel

The Figures obtained are plotted between means of all parameters individually, and S/N ratio and all parameters, so that, the larger the better values, identified easily.

Taguchi Analysis Graphs for Medium Carbon Steel

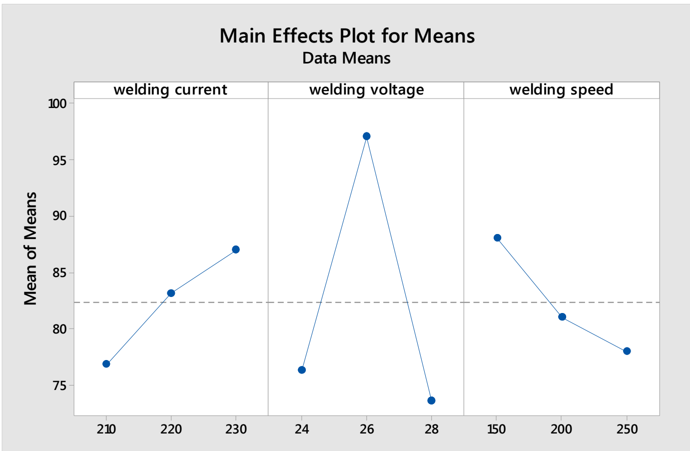

Figure 5: Main Effect Plot for Means for Low Carbon Steel

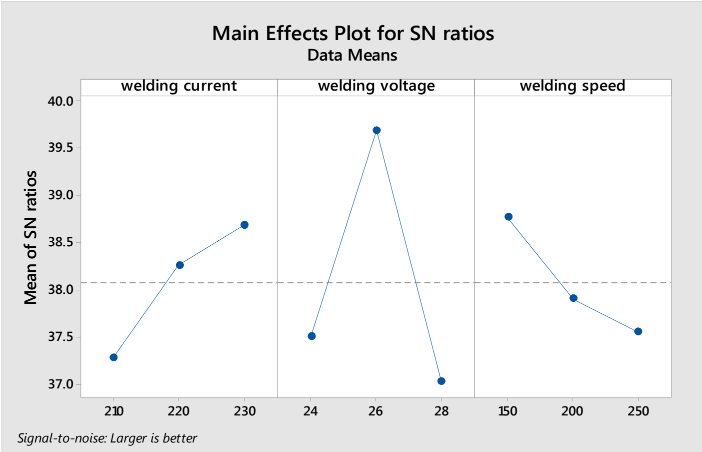

Figure 6: Main Effect Plot for S/N Ratio for Medium Carbon Steel

From the above figures, it is inferred that the highest point values between means and S/N ratio to all individual parameters, are the optimal parameter values for welding.

Response Table for Signal to Noise Ratios for Low Carbon Steel

Larger is Better

Table 11: Values of Larger is Better Low Carbon Steel

Level	Current	Voltage	Speed
1	28.37	26.15	27.99
2	27.56	28.18	26.35
3	27.94	29.54	29.53
DELTA	0.81	3.39	3.17
RANK	3	1	2

Response Table for Signal to Noise Ratios for Medium Carbon Steeel

Larger is Better

Table 12: Values of Larger is Better Medium Carbon Steel

Level	Current	Voltage	Speed
1	37.27	37.50	38.76
2	38.25	39.68	37.89
3	38.68	37.02	37.55
DELTA	1.41	2.66	1.21
RANK	2	1	3

The above response table gives the result of parameter as up to what level, and which parameter effects the welding. Delta is the value of difference of higher value S/N ratio to the second higher value of S/N ratio, and rank is given according to the highest value obtained from ranking.

CONCLUSIONS

The optimization of parameters by the Taguchi's orthogonal array has proved to be an excellent tool. This experimentation has provided a significant result, by considering small experimentation values. The three parameters are contributing to the response, and all have been considered for experimentation of MIG welding. Among the parameters, the optimal parameters combination of Low Carbon Steel for higher tensile is speed 300mm/min, voltage 27 volts and

current 180amps. Among the parameters, the optimal parameters combination of Medium Carbon Steel for higher tensile is speed 150mm/min, voltage 26 volts and current 230amps. The S/N ratios of predicted values and verification test values are valid when compared with optimum values. The S/N ratios are found to be within the limits of the predicted value, and the work has fulfilled the objective. Hence, it can be concluded that, the parameters are valid and within the range of the machining standards.

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